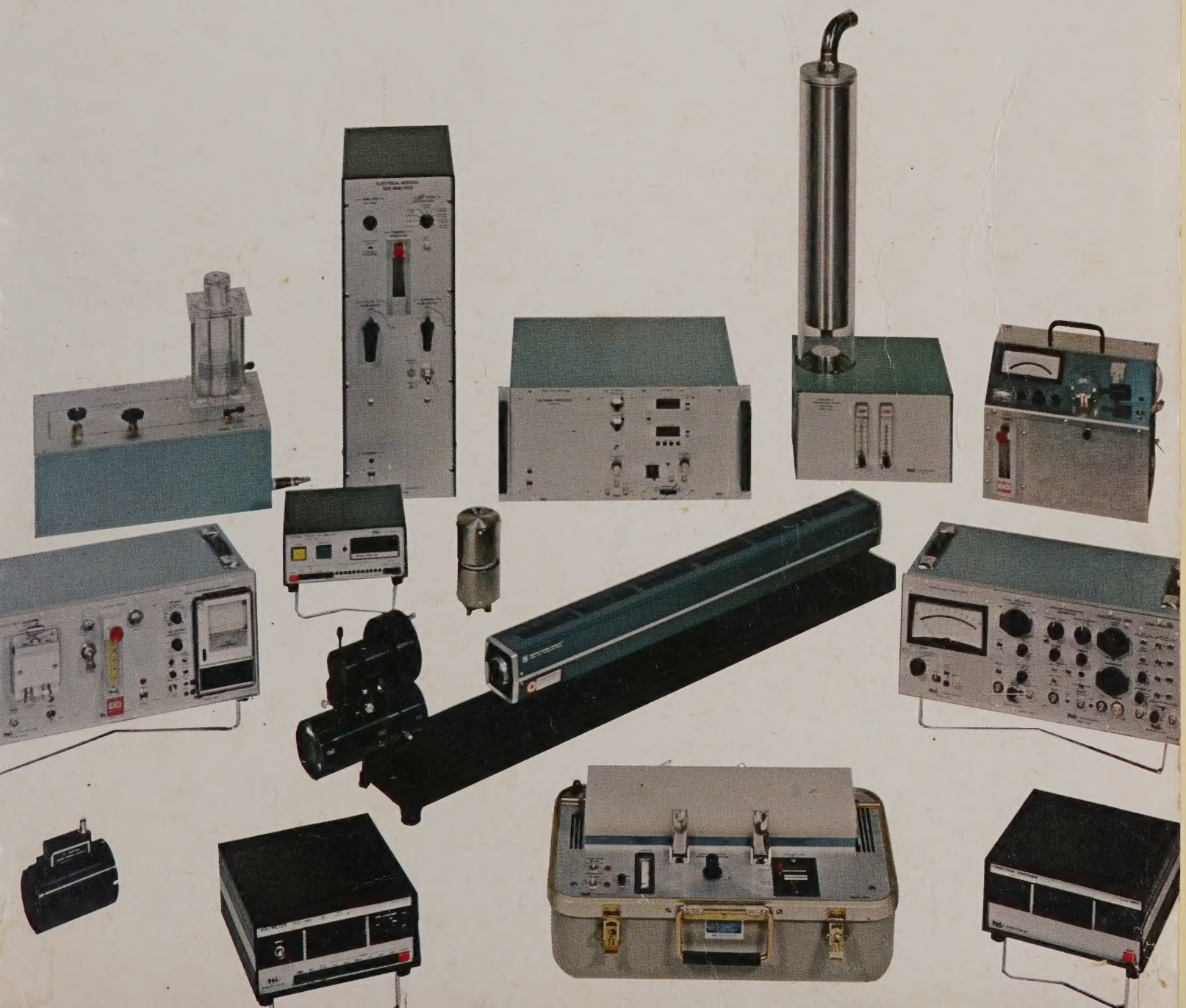
THERMO-SYSTEMS INC.

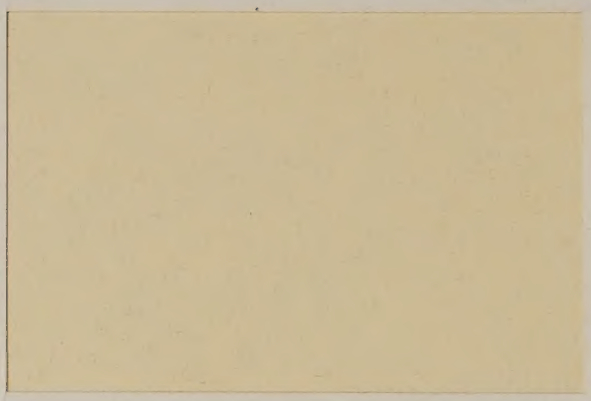
INSTRUCTION MANUAL

FOR

MODEL 1076 RMS VOLTMETER



THERMO-SYS RMS VOLTMTR 1076



INSTRUCTION MANUAL

FOR

MODEL 1076 RMS VOLTMETER

THERMO-SYSTEMS INC

CERTIFICATION & WARRANTY

Thermo-Systems Inc. certifies that this instrument has been thoroughly inspected and tested and found to meet its published specifications when shipped from the factory. This product is warranted against defects in material and workmanship for a period of one year from the date of delivery. We will repair or replace products which prove defective during the warranty period. No other warranty is expressed or implied. We are not liable for consequential damages.

Knowing that inoperative or defective instruments are as detrimental to Thermo-Systems as to our valued customers, our service policy is designed to give prompt attention to any known problems. Please contact the TSI factory, sales office or your nearest representative if any malfunction should be discovered.

SPECIFICATION SHEET

MODEL 1076

GENERAL

Type: Solid State Analog Computing Circuit

Functions: Front Panel Selection for RMS, Mean Square, or DC

Averaging Time: Front Panel Selection for 0.1, 1, 10 or 100 seconds

Output: BNC Connector on Back, Range = 0 - 1 volt Full Scale for all Functions and Ranges. Output Impedance = 10 ohms, 10 ma Max. Current.

Auxiliary Functions: (Rear Terminals)
1) Instantaneous Squared Output-e^2
2) Auxiliary Input to Averaging Circuit

Imput Impedance: 1 Megohm

Meter: Digital (4 digits). Auto Zero on DVM

Power Supply: 110/220V AC $\pm$ 10%, 50 to 400 Hz, Approximately 15 Watts

Size: 8.5" (216) wide x 11" (280) deep x 3.5" (89) high. Two units can be connected side by side for rack mounting - 3.5" height, also, units can be stacked for multiple applications.

Weight: 7.7 Pounds (3.5 Kg)

Furnished With: Power Cord, 3' Coax Interconnect Cable and Instructions

Accessories: Model 10166 Rack Mtg. Kit - Contains Hardware for Clamping Two Units Side by Side and Mounting in Standard 19" Relay Rack - 3.5" High
Model 10165 Multi-Channel Kit-Contains Hardware for Clamping either Two or Four Units Together - With Convenient Handles.

Dan Kistner

RMS AND MEAN SQUARE

Ranges: 6 Ranges
RMS: 1, 10, and 100 mv; 1, 10,and 100V full scale
Mean Square: 10^{-6}, 10^{-4}, 10^{-2}, 10^{0}, 10^{2}, 10^{4} volts^2 full scale

Crest Factor: 10 at full scale, 50 at 0.20 of full scale (range change point) for 0.1 Hz to 100 KHz. At 500 KHz, full scale crest factor is 5.

Accuracy and Frequency Response (from 20% to 200% of F.S. on each range):
RMS: $\pm$1% of reading, 0.5 Hz to 100 KHz
$\pm$10% of reading,0.1 Hz to 0.5 Hz and 100 KHz to 500 KHz

Mean Square: $\pm$ 2% of reading, 0.5 Hz to 100 KHz
$\pm$ 20% of reading,0.1 Hz to 0.5 Hz and 100 KHz to 500 KHz
Digital Readout: Add $\pm$ 2 digits to above accuracies

TEMPERATURE STABILITY:

Less than 0.05%/$^{\circ}$C from 20°C to 40°C. (Zero adjust and internally referenced gain adjust are provided for convenient long term calibration adjustments.)

DC VOLTMETER

Ranges: 2 Ranges, 1 Volt and 10 Volts Full Scale

Accuracy: $\pm$ .05% $\pm$ 2 Digits

Temperature Stability: 100 PPM/$^{\circ}$C

Options:
01 - BCD Output
02 - Logarithmic Output (Contracted Scale)
03 - External Hold
04 - Automatic Ranging

THERMO-SYSTEMS INC.
2500 CLEVELAND AVENUE NORTH ST. PAUL MINNESOTA 55113 612-~~633-8550~~

4830900

TABLE OF CONTENTS

		Page
SECTION I GENERAL INFORMATION AND INSTALLATION		
1-1	INTRODUCTION	1
1-2	INSTALLATION	1
SECTION II OPERATING INSTRUCTIONS		
2-1	INTRODUCTION	2
2-2	FUNCTIONAL DESCRIPTION OF EXTERNAL CONTROLS AND TERMINALS	3
2-3	DETAILED OPERATING PROCEDURE	5
SECTION III CIRCUIT DESCRIPTION		10
SECTION IV SERVICE INFORMATION		
4-1	GENERAL LAYOUT	12
4-2	CALIBRATION PROCEDURES	13
SECTION V THEORY		18
SECTION VI AUTOMATIC RANGING (OPTION 04)		22
SECTION VII BCD OUTPUT (OPTION 01)		24

SECTION I

GENERAL INFORMATION AND INSTALLATION

1-1 INTRODUCTION

The primary function of the Model 1076 is the measurement of the true rms value of the signal connected to the input. For added convenience and utility, the mean square value and the average DC level can also be measured with the same meter. The Model 1076 is particularly useful where the low frequency response (0.1 Hz) and long time constants (100 sec) are required.

1-1.1 INSTRUMENT DESCRIPTION

The accuracy of the Model 1076 permits covering the range from 1 mv rms full scale to 100 volts rms full scale with only 6 ranges. The use of a 4 place digital readout permits taking full advantage of this wide range.

The frequency range is 0.1 Hz to 500 KHz with a crest factor of 10 at full scale. At 1/10 of full scale, this gives a crest factor of 100. True rms measurements can be made with a duty cycle of only 1 percent.

True rms, mean square, or DC voltage can all be read directly on the meter. A 0 - 1 volt analog output on the back panel is in parallel with the meter. For DC, only the 1 and 10 volt ranges are operable. All three functions utilize the variable time constant feature.

1-2 INSTALLATION

The instrument was carefully inspected both mechanically and electrically before shipment. There should be no marks, scratches, missing components or accessories, or malfunction in electrical performance. If there is any deficiency contact Thermo-Systems or your nearest TSI representative. In

addition to the instrument itself, a power cord and instruction manual are included.

Before connecting to power source, observe position of switch in the "window" to the upper left of the back panel handle. This will read either 115 or 230, which refers to 115V AC or 230V AC. If set incorrectly for your power line, insert a tool in the slot provided and slide the switch horizontally until the other number appears.

SECTION II

OPERATING INSTRUCTIONS

2-1 INTRODUCTION

The instrument is easy to use. The function (RMS, DC, mean square) is selected by the three push button switches to the left. Six push button switches select the range. The time constant is selected with the rotary switch to the right of the digital meter. This switch also turns on the power. The input is connected to the left of the meter. The push-button switch to the far right selects either auto or manual. If the unit does not have auto-ranging, this switch as well as the range indicator lights are not connected. (See Section VI for auto-range information if included,)

IMPORTANT!

A) ZERO the meter with the mean square button depressed, in the 0.1 time constant position, and on the 1 V range.

B) CALIBRATE the meter with the RMS button depressed and in the CAL time constant position.

Full scale for the mean square function is on the back panel. Full scale on DC can be set using an internal potentiometer (see service section). Due to the square root relation, there is no zero set for rms. The mean square zero fulfills that function. It should be noted that while full scale is 1.000, the digital meter has a full scale of 9.999. Therefore, as explained in section 2-2 A1 below, the digital voltmeter will not overrange, and exceeding 1.000 will decrease the crest factor. At the same time, the extended capability of the panel meter is sometimes convenient.

2-2 FUNCTIONAL DESCRIPTION OF EXTERNAL CONTROLS AND TERMINALS

A) Front Panel

1) Meter. This is a 4 digit meter that has a full scale of 9999. This full range can be used in the 1 VDC and 10 VDC positions. In RMS or MS, measurements over the 1.0 volt full scale can be made but the crest factor will decrease proportionally. For a true sine wave (required crest factor of 1.41) measurements up to 7071 on the meter will be accurate. This essentially gives 700 percent overranging. On mean square, a meter reading of 9999 represents a 333 percent input overrange with a crest factor of 3.

Overrange on the panel meter (above 9999) is indicated by a 10000 reading with the 1 blinking.

2) Function Switches. The three push buttons on the far left select whether RMS, DC, or mean square values are to be measured.

3) Range Switch.

   a) RMS full scale range of 1 mv to 100 volts can be selected from the six push button switches.

   b) Mean Square. To obtain mean square range, the indicated output must be multiplied by the range. This gives mean square ranges from 10^{-6} volts full scale (1 mv squared) to 10^{4} volts full scale (100 volts squared).

   c) DC. The DC range reads directly in volts, but is functional only on the 1 volt and 10 volt scale.

4) Power Switch. The time constant switch must be turned clockwise to energize the instrument.

5) Input. The voltage to be measured is connected here. It must not exceed 200 volts peak on any range.

6) Time Constant. This switch selects both the averaging time and the high pass filter on the input. A time constant of one second means that the unit will reach 63 percent of its final value in one second, 86 percent in 2 seconds, and 95 percent in 3 seconds (in DC, add 1 second to indicate time constant). The "CAL" position is used to adjust the "CAL" potentiometer so the unit reads the proper full scale value in the RMS function position. (Also back panel adj. for mean square.)

7) Zero. The zero adjustment on the front panel is used for the mean square function. To adjust, put the time constant switch in the 0.1 position and the range switch in the 1V position.

8) CAL. This sets full scale properly for the RMS function. To adjust, put Time Constant switch in CAL and set potentiometer so output reads 1.000.

B) Back Panel (Figure 1)

1) Fuse. Use 1/4 ampere fuse (115 VAC line voltage).

2) Line Switch. Permits using unit on either 115V AC or 230V AC power lines.

3) Power Jack. For plugging in the line cord.

4) MS Adj. Used to set full scale in the mean square function.

5) Output. This is a 0 - 1 volt output for whatever function is selected on the front panel. This output will actually go to 10 volts with good accuracy as long as crest factor considerations permit this much overrange (see 2-2 A1).

6) Terminal Strip.

a) Position 1 - Signal Ground

b) Position 2 - NC (Log Out with 02 option)

c) Position 3 - External Hold (option 3)

d) Position 4 - Amplified Input

e) Position 5 - Averaging Circuit Input

f) Position 6 - Squared output before averaging

7) BCD Output - Only on units with 01 option.

2-3 DETAILED OPERATING PROCEDURE

A) Turn on and Calibration Procedure:

Check back panel for proper line voltage (Figure 1) and then connect to AC power line. Turn the Time Constant switch to energize the unit. Allow 15 minutes for warm-up. The zeroing procedure is then as follows:

1) Ground the input
2) Set TIME CONSTANT to 0.1
3) Depress DC function switch and 1V rnage switch
4) Unit should read zero. If not, adjust R10 on Time Constant board (av. ckt. zero).
5) Depress MEAN SQUARE function switch
6) Adjust ZERO potentiometer on front panel
7) Set Time Constant switch to CAL
8) Adjust MS Adj on rear panel so meter reads 1.000
9) Depress RMS function switch
10) Adjust CAL potentiometer on front panel so meter reads 1.000.

This completes the normal set-up. For further calibration instructions, see Section IV. The AV. CKT. ZERO (R10) should be correct for RMS measurements as well as MEAN SQUARE and DC. Therefore, items 1 - 4 must be followed for DC measurements and items 1 - 9 for RMS or MEAN SQUARE measurements.

The RMS output will not give an accurate ZERO. This is due to the nature of the square root circuit. However, the MEAN SQUARE zero sets the system correctly for RMS measurements to less than 10 percent of full scale. To check the RMS reading at the low end of the scale, first measure mean square. The RMS value should be the square root of this value.

B) Connecting Signal

With the TIME CONSTANT switch in the 0.1 position, connect the signal to be measured to the input. Depress the proper switch for the desired function (RMS, DC. or MEAN SQUARE).

C) Selecting Range

1) DC measurements

Here, the 1 volt scale is normally used. Including the overrange, it will measure to 9.999 volts with a 1 mv resolution. In the 10 volt position, it will measure to 100 volts with a 10 mv resolution. The analog output on the back panel is 0.1 times the input signal in the 10 volt position.

2) RMS measurements

If the panel meter reads below 100 (independent of decimal point) select a more sensitive scale. If it reads above 1000, select a less sensitive scale. If the meter indicates 10000 with the "1" blinking, the panel meter is overranged and a position two ranges less sensitive should be tried.

As mentioned briefly in section 2-2 A1, accurate measurements can be made above an indication of 1000 if a decrease in crest factor below 10 is permitted. A sine wave, for example, requires a crest factor = $\sqrt{2}$. Therefore, measurements up to an indication of 7071 are accurate with a sine wave input. This gives a range of over 70:1 without switching ranges. For random noise, a crest factor of at least 3 should be used (maximum full scale reading of 3333).

3) Mean Square measurements

If the panel meter reads below 10 (independent of decimal point) select a more sensitive scale. If it reads above 1000,

select a less sensitive scale. If the meter indicates 10000 with the "1" blinking, the panel meter is overranged and a less sensitive scale should be selected.

As mentioned in section 2-2 A1, accurate measurements can be made above an indication of 1000 if a decrease in crest factor below 10 is permitted. In the case of mean square, a reading of 9999 on the meter still leaves a crest factor of 3.333. This is adequate for sine waves and many noise measurements.

D) Selecting the Time Constant

The proper range is normally found with the TIME CONSTANT switch in the 0.1 position. If a longer time constant is desired, switch to the 1 sec position and wait for a proper reading (at least 3 sec). Then switch to the 10 or 100 second position if required.

The following table gives the important data on the four time constant positions for rms and ms:

Time Constant (Seconds)	Minimum Frequency, Hz (3 db point)	Output Ripple at Minimum Frequency, %
0.1	19	6
1	1.5	4
10	.06	17
100	.06	1.7

The meaning of these is as follows:

Time Constant: With a step change in the input, the output will reach 63 percent of its final value in this time (86 percent in 2 time constants, 95 percent in 3 time constants, 98 percent in 4 time constants).

Minimum Frequency, Hz: Minimum frequency accepted by input circuitry (3 db point of high pass filter).

Output Ripple: Ripple on output of rms meter when input is a sine wave at the minimum frequency.

Some output ripple at the minimum frequency was intentionally left to indicate that the unit should be switched to a longer time constant to include all the frequencies present.

It should be noted that the TIME CONSTANT switch affects only the averaging time and the high pass filter on the input. The high frequency response is not affected by the TIME CONSTANT switch.

E) Outputs

The primary output is on the BNC jack on the back panel of the instrument. This output is the same voltage as that fed to the panel meter. It is a low impedance (10 ohms) output that will drive most recording or indicating equipment.

The other outputs are available for special applications. The amplified input signal is on position 4 of the terminal strip. This output has a 1K output impedance and a $\pm$ 10 volt maximum signal amplitude. A second output is the instantaneous squared output

(position 6). This is useful for some correlation work. It should be noted that frequency response of this output is somewhat less than that of the unit when used normally.

The 02 option gives a logarithmic output on position 2. This is particularly useful for recording or controlling where the wide range of the instrument (without range switching) is utilized.

Terminal 5 represents the averaging circuit input. This, again, is useful to have available for certain correlation work using anemometers.

SECTION III

CIRCUIT DESCRIPTION

The Model 1076 utilizes a precision rectifier and logarithmic amplifier to perform the squaring and square root functions. A simplified block diagram of the unit is shown on the specification sheet. The system is all solid state and designed to give accurate, stable readings of mean square and true rms voltages.

The input amplifier has a fixed gain of 1,000. Attenuations on the input of factors of 1, 10, 10^2, 10^3, 10^4, and 10^5 are selected by the range switches on the front panel. The signal is rectified by a precision rectifier. A unique feedback circuit both corrects for zero drift and provides the high pass filter for the input amplifiers.

The signal is squared by taking the log, multiplying by 2, and then taking the anti-log. Averaging this output directly gives the mean square. To obtain RMS, the log of the output is fed back to the input of the anti-log circuit. The RMS output is now obtained by averaging the output of the anti-log amplifier.

In the DC function, only the averaging circuit and panel meter are utilized. A separate attenuator is provided to switch between the 1V and 10V positions.

The appropriate equations for the signal as it proceeds through the unit may be helpful. The output of the input amplifier is

$$\text{Output}_{IA} = \frac{\text{Input}}{\text{Range}} \tag{1}$$

An input signal of 50 mv peak to peak will give an output of 0.5 volt when on the 100 mv range. To obtain the 10:1 crest factor, the input amplifier actually has a maximum output amplitude of 10 volts.

After the rectifier, Eq. (1) becomes

$$(\text{Output})_R = \left|\frac{\text{Input}}{\text{Range}}\right| \tag{2}$$

In MEAN SQUARE, the output of the logarithmic squaring circuit is:

$$(\text{Output})_{MSI} = 0.1 \left(\left|\frac{\text{Input}}{\text{Range}}\right|\right)^2 \tag{3}$$

Adding the averaging circuit (GAIN = 10) gives:

$$(\text{Output})_{MSA} = \overline{\left(\left|\frac{\text{Input}}{\text{Range}}\right|\right)^2} \tag{4}$$

which is the MEAN SQUARE.

For the RMS, the output of the logarithmic squaring circuit is

$$(\text{Output})_{\text{RMSI}} = 0.1 \frac{\left(\left|\frac{\text{Input}}{\text{Range}}\right|\right)^2}{\sqrt{\left(\left|\frac{\text{Input}}{\text{Range}}\right|\right)^2}} \qquad (5)$$

Adding the averaging circuit gives:

$$(\text{Output})_{\text{RMSA}} = \sqrt{\left(\left|\frac{\text{Input}}{\text{Range}}\right|\right)^2} \qquad (6)$$

This is the true rms value.

In the DC mode, the signal is first attenuated by a factor of 10 (100 in 10V)position to compensate for the gain of 10 in the averaging circuit. Basically, the DC position simply utilizes the averaging circuit to give a variable time constant to DC readings on the front panel digital meter.

SECTION IV

SERVICE INFORMATION

4-1 GENERAL LAYOUT

The Model 1076 is released from the cabinet by simply turning the screw in the lower center of the back panel to the left. The entire chassis can then be slid out the front of the extruded aluminum case.

Most of the input amplifier and attenuator section is enclosed in a metal shield along the side of the unit just behind the input jack. The last gain stage is located on the "mother" board between the end of the metal shield and the back panel. The output of the input section is

connected to position 4 on the terminal strip as well as going to the last wafer on the TIME CONSTANT switch so it can be switched out for the "CAL" position. From there the signal goes to the log board.

The "TIME CONSTANT" switch is attached directly to the T.C. board assembly. The feedback for the auto-zero and high pass filter are located on this board. A third switch wafer is for the averaging time as discussed later.

The log board assembly is located in the center of the unit between the digital meter and the transformer. It includes the precision rectifier, log amplifier, and anti-log amplifier. The output from this board is brought out to position 6 on the terminal strip. Through a jumper it goes into the input of the averaging circuit located on the T.C. board assembly.

The output of the averaging circuit is connected to the output jack on the back panel and the digital panel meter. In the RMS position, a logaritmic amplifier on the "mother" board feeds the log of the output back to the input of the anti-log amplifier. The other components on the "mother" board are for the $\pm$ 15V and + 5V power supply.

4-2 CALIBRATION PROCEDURES

The unit should be properly calibrated on receipt and should remain within specification for 6 months using only the external adjustments and the averaging circuit zero (R10 on time constant board). However, for customer convenience the Model 1076 can be calibrated in the field using the following procedures. A complete set of prints is enclosed to assist in finding the indicated adjustments.

4-2.1 POWER SUPPLY

1) Adjustment. Set R53 so 15 volt supply (position 8 on T.C. board connector) reads exactly 15.000 volts.

2) Check. -15 volt supply should be within ± 1 percent (position 7 on T.C. board).

3) Check. +5 volt supply should be within ± 0.2 volt.

4-2.2 DC CALIBRATION

This checks the digital panel meter and the averaging circuit for proper operation. Proceed as follows:

1) Input Jack - Grounded

2) Function - DC

3) Range - 1V

4) TIME CONSTANT - 0.1

5) Adjustment - Set AV. CKT. ZERO (R10 on T.C. board).

6) Input Jack - 9V DC signal from external signal source.

7) Adjustment. Set R9 on mother board so the digital panel meter reads 9.000.

8) Input Jack - 90V DC signal from external signal source.

9) Range - 10V

10) Adjustment. Set R69 on mother board so the digital panel meter reads 90.00.

This completes the DC calibration.

4-2.3 MEAN SQUARE AND RMS CALIBRATION

This is considerably more complex than the DC since it involves all ranges as well as the log-anti log board. Instruments required include:

1) Sine wave generator
2) Accurate AC voltmeter
3) Accurate DC voltmeter

4-2.3.1 INPUT AMPLIFIERS ZERO AND GAIN

1) Input Jack - Grounded
2) Function - Mean Square
3) Range - 1 mv
4) Time Constant - 0.1
5) Adjustment. Set R7 on T.C. board so R of SW1-1 (rotor of center wafer on T.C. switch) reads zero.
6) Time Constant - 0.1
7) Input Jack - 1 KHz Sine Wave input with amplitude of 1 mv (as read with AC voltmeter)
8) Adjustment. Set R4 on mother board so the output of the input amplifier (position 4 of terminal strip) reads 1 volt (as read with AC voltmeter)
9) Range - 10 mv
10) Input Jack - 1 KHz sine wave input with 10 mv amplitude
11) Adjustment. Set R22 on input board so position 4 of terminal strip reads 1 V on AC voltmeter
12) Range - 100 mv
13) Input Jack - 1 KHz sine wave input with 100 mv amplitude

14) Adjustment. Set R_{18} on input board so position 4 of terminal strip reads 1V on AC voltmeter

15) Range - 1V

16) Input Jack - 1 KHz sine wave input with 1V amplitude

17) Adjustment. Set R3 on input board so position 4 of terminal strip reads 1V on AC voltmeter

18) Check. The 10V and 100V positions should require no adjustments. They can be checked by depressing the 10V or 100V range switch, putting in a 10V or 100V input signal respectively, and checking the output for 1V amplitude.

4-2.3.2 FINAL ADJUSTMENTS

1) Input Jack - Grounded

2) Function - Mean Square

3) Range - 1 v

4) Time Constant - 0.1

5) Adjustment. Set zero potentiometer on front panel so digital panel meter reads zero.

6) Input - 1 KHz sine wave with amplitude of 1 v (as read with AC voltmeter)

7) Adjustment. MS adj. on rear panel so digital panel meter reads 1.000

8) Function - RMS

9) Adjustment. Set Cal potentiometer on front panel so digital panel meter reads 1.000

10) Time Constant - Cal.

11) Adjustment. Set R3 on time constant board so digital panel meter reads 1.000.

When the above adjustments are made, the unit should perform to specifications over the entire frequency and voltage range and in all functions. If there is still a problem, it may be in the log board. The set-up of this is quite complex and normally the unit should be returned to the factory. If the customer does desire to set this, then please write to factory for detailed instructions.

SECTION V

THEORY

In research and engineering, measurement of the variables in the system of interest is always required for experimental data. In many cases only the average value is measured. This can also be called the "steady state" value. In other situations an exact time history of the variable is required. In both these cases rapid fluctuations that might be present are often "filtered" out by slow response equipment. The response of the instrument then defines which changes are measured and which are to be ignored as meaningless fluctuations about the mean value.

In many processes, the "flutuations" are in fact an important parameter and cannot be ignored. Since averaging essentially eliminates fluctuations a different measurement must be made. The most common measurements are the mean square and root mean square. The mean square is:

$$\overline{f_A^2(T)} = \lim_{T \to \infty} \frac{1}{T} \int_{-T/2}^{+T/2} f_A^2(t)\, dt \qquad (1)$$

where:

$f_A(T)$ = instantaneous value of the signal

T = time

The root mean square value is:

$$\sqrt{\overline{f_A^2(T)}} \qquad (2)$$

Although $f_A(T)$ could be any function varying with time, a transducer has normally converted it to a voltage for measurement purposes.

In actual practice, the mean square meter or root mean square meter is generally coupled with a capacitor so DC voltages are not processed. Therefore, the measurement is really a variance or standard deviation measurement where:

$$\overline{f_A^2(T)} = \left(\overline{f_A^2(T)}\right)^2 = \lim_{T\to\infty} \frac{1}{T} \int_{-T/2}^{+T/2} [f_A(t) - \overline{f_A(t)}]^2 \, dt \qquad (3)$$

The first term on the right is the average value while the second term is the variance. The standard deviation is then:

$$\left[\lim_{T\to\infty} \frac{1}{T} \int_{-T/2}^{+T/2} [f_A(t) - \overline{f_A(t)}]^2 \, dt \right]^{1/2} \qquad (4)$$

Therefore, the mean square measurement with the Model 1076 is truly a measurement of variance while the root mean square is a standard deviation measurement. The use of this terminology is not meant to mislead but only follows standard practice in the instrumentation field. In the following we shall use the term mean square and root mean square even though the mean value is not present.

In equation (3), letting T approach infinity is not practical. Therefore, an averaging time must be selected. In addition, when separating out the mean value a low frequency cut-off for the meter must be selected. Fluctuations below this frequency will then be considered changes in the average value while fluctuations above this frequency are considered variations about the mean.

In the Model 1076 the table in Section 2-3D gives the range of averaging times and associated low frequency cut-offs available on the TIME CONSTANT switch. The low frequency cut off is selected such that the meter output will fluctuate if low frequencies are present. Therefore, if the meter is not steady a longer time constant must be selected to get a true value of the mean square or root mean square. If only a certain bandwidth is of interest, a filter should be used ahead of the meter. In other words, the low frequency cut-off of the meter is not intended to be used as a high pass filter although it can be used this way for approximate measurements.

The term "true" root mean square meter is often utilized. The Model 1076 and similar meters that basically measure what is indicated in Eq. (4) are "true". The

implication is that some meters are not "true". These latter units are essentially rectifier units that give an accurate root mean square reading only on a sine wave input. A "true" rms meter, or one that satisfies Eq. (3) should give an accurate reading independent of wave shape as long as the bandwidth and crest factor limitations of the meter are not exceeded.

Bandwidth concerns both the low frequency cut-off discussed above and the high frequency capability of the meter. The maximum frequency response of the meter should be higher than the frequencies expected in the signal. On the Model 1076, 500 KHz is the upper frequency limit with 0.1 Hz the lower limit.

Crest factor is another important parameter for a mean square or root mean square meter. It is defined as the ratio of the peak voltage to the root mean square voltage or:

$$C.F. = E_{Peak}/E_{rms}$$

A full scale crest factor of 10, such as on the Model 1076, is about the maximum available. At less than full scale the crest factor goes up proportionally as would be expected. For example, at half scale the crest factor would be 20 on the Model 1076.

Another way of expressing crest factor is the ratio of on to off time of a pulse applied to the input. If we let

$$D = T/T_o$$

where:

T_o = time for complete cycle

T = pulse on time during cycle

then:

$$C.F. = \frac{1 - D}{D}$$

For a crest factor of 10, D = 1/101 or the off time is 100 times the on time for the pulse. This ratio is acceptable even with full scale output.

The bandwidth and crest factor of the Model 1076 were specifically selected with fluid and solid mechanics in mind. For example, turbulence measurements in water often requires useful data down to the 0.1 Hz range. Even in wind tunnels, tunnel noise is on the order of tunnel dimensions. At 20 ft/second velocity, eddies that take several seconds to go past are easily conceivable in a large tunnel.

A high crest factor is very important when making mean square or root mean square measurements in fluid and solid mechanics. Again using a fluid mechanics example, transition to turbulence can give large "spikes" in the signal when compared to the mean level. Other examples would be in non-steady shock patterns in supersonic flow.

SECTION VI

AUTOMATIC RANGING (OPTION 04)

With this option, the unit automatically selects the correct RMS range when the AUTO button (far right) is depressed. The automatic ranging can be used in mean square by re-setting the lower limit potentiometer (R9) as discussed below. The auto-ranging is not operable in the DC mode. The following discusses the operation in RMS.

A range change is initiated when the output either goes above the high limit or below the low limit. The high limit is set at an indicated reading of 200 $\pm$ 60. This is equivalent to 1.2 volts on the wiper of potentiometer R9 (see schematic of auto-range option).

For RMS, the low limit is set at an indicated reading of 100 $\pm$ 5. This is equivalent to a reading of 0.10 on the wiper of potentiometer R5.

For automatic operation in Mean Square, potentiometer R5 must be set to 0.01 volts. This is because in mean square each range must cover a 100:1 variation. The auto-ranging feature is not operable in the DC mode.

To understand the operation, some special features should be noted:

1) Once a limit is passed so a range change is initiated, another range change cannot be started until after a time interval equal to four time constants. The time constant involved is the one set on the front panel time constant switch.
2) In the 10 and 100 second time constant position, the unit will internally switch to the 0.1 second time constant position for 5 seconds after initiation of a range change. This speeds up settling time.

3) On the 100 second time constant position, a large change in input signal can require several minutes before the final reading is reached. For example, if 3 range changes were involved (e.g., 10 mv to 10V), the unit would spend 400 seconds (4 time constants) in the 100 mv and 1V ranges. Adding another 4 time constants to achieve the correct reading on the 10V range gives a total time of 1200 seconds or 20 minutes.

Item (3) shows the desirability of initially locating the correct range manually using shorter time constants. In an actual auto-ranging situation, it is unlikely more than one range change would be involved at any one time. Also, the 5 second time in the 0.1 position helps greatly in approaching the true reading earlier than 4 time constants.

SECTION VII

BCD OUTPUT (OPTION 01)

The Model 1076 has two kinds of digital signals. One set comes from the digital panel meter itself. This consists of eight lines which read out the digital values in serial form. Four lines (J9-1, 2, 3, and 4) are the 1, 2, 4 and 8 BCD lines while the other four lines (J9-11, 12, 13, 14) indicate whether the ones digit, tens digit, hundreds digit, or thousands digit are being read out. These eight lines have low drive capability - 150μ a maximum.

The second set of lines establish the range the meter is in. J9-20, 21 and 22 are used for this. J9-22 is high for the volts range and low for the millivolt range. If both J9-20 and 21 are high, the range is either 1 mv or 1 V depending on J9-22. If J9-21 is low, the range is 10 (mv or V) and if J9-20 is low the range is 100.

Two other lines are used for interfacing. J9-5 will hold the last reading on the meter when it is grounded. J9-6 indicates by a "low" when the meter is taking the next reading. Generally, for interfacing it is only necessary for the data acquisition system to ground J9-5 while it is taking the reading so the output does not change during data acquisition.

THERMO-SYSTEMS INC.
2500 CLEVELAND AVE. NO. ST. PAUL, MINNESOTA 55113 612-633-0550 TELEX 297-482 CABLE THERMOSYS

MODEL 1076-01

BCD CONNECTOR PIN FUNCTIONS

J9 CONNECTOR PIN NO.	FUNCTION
1	LSB BCD out "1"
2	BCD Out "2"
3	BCD Out "4"
4	BCD Out "8" MSB
5	Hold (Ground to hold reading)
6	Busy/Done Output (Lo-Busy)
8	+5V
10	Logic Ground
11	STROBE 10^0 Decimal
12	STROBE 10^1 Decimal
13	STROBE 10^2 Decimal
14	STROBE 10^3 Decimal
20	Decimal Point (100) (Lo)
21	" " (10) (Lo)
22	mv (Lo)

Notes: Lo on Strobe during readout of that decimal digit

Both 20 and 21 high, Decimal Point (1)

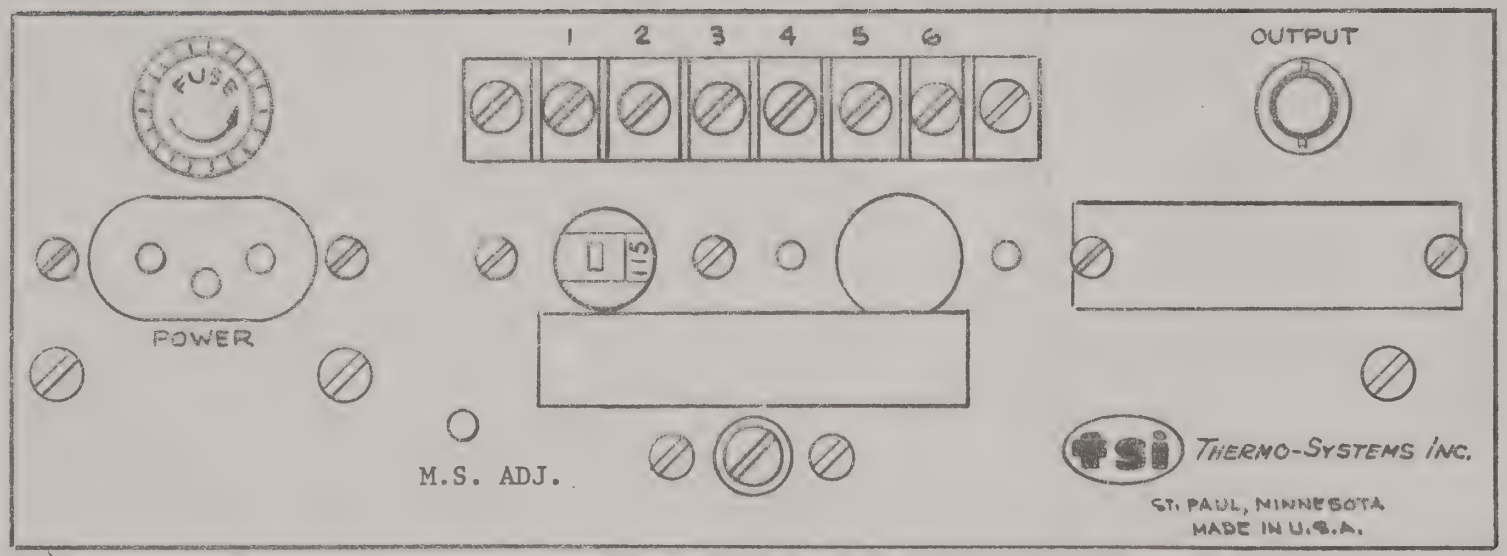


FIGURE 1. BACK PANEL OF MODEL 1076

A1 INPUT BOARD ASSY
NO SA5143

A2 LOG BOARD ASSY
NO. SA5144

A3
T.C. BOARD ASSY
NO. SA5145

A4
AUTO-RANGE BOARD ASSY
SA5148
SEE SHEET 2 FOR CIRCUIT

A5 MOTHER BOARD ASSY
NO. SA5146

EXTERNAL JUMPER

OUTPUT J7

J9 BCD CONNECTOR

FOR SN's 069 & UP

1 - FOR ANALOGIC METER (MD1034) ONLY
2 - FOR AUTO RANGE OPTION ONLY (-04)
3 - INSTALL JUMPER BETWEEN (19) & (20) AT CHECK OUT
4 - ALL DIODES ARE IN457 UNLESS OTHERWISE SPECIFIED
5 - A2R14 & A2R15 TO BE A MATCHED TO EACH OTHER WITHIN 0.1% FROM 7% LTC RESISTORS
6 - ½ DENOTES TERMINAL BOARD NO. (TB1), TERMINAL 2
7 - ⬡ DENOTES WIRING PAD OR TERMINAL
8 - ALL RESISTORS ARE 1/4W AND/OR 5% UNLESS OTHERWISE SPECIFIED
9 - ALL CAPACITANCE IN μF AND ALL RESISTANCE IN OHMS UNLESS OTHERWISE SPECIFIED

A3 - FOR EXTERNAL HOLD OPTION ONLY (-03)
A2 - FOR LOG OUTPUT OPTION ONLY (-02)
A1 - FOR BCD OPTION ONLY (-01)
A6 - FOR NON-LINEAR SYSTEMS METER (MD1044) ONLY

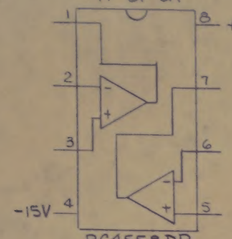
THIS DOCUMENT CONTAINS CONFIDENTIAL INFORMATION OF THERMO-SYSTEMS INC. IN CONSIDERATION OF THE RECEIPT OF THIS DOCUMENT THE RECIPIENT AGREES NOT TO REPRODUCE, COPY, USE OR TRANSMIT THIS DOCUMENT AND/OR THE INFORMATION THEREIN CONTAINED, IN WHOLE OR IN PART, OR TO BUFFER SUCH ACTION BY OTHERS, FOR ANY PURPOSE EXCEPT WITH THE WRITTEN PERMISSION OF THE THERMO SYSTEMS INC.

tsi THERMO-SYSTEMS INC.
2500 CLEVELAND AVE N ST PAUL MINNESOTA 55113

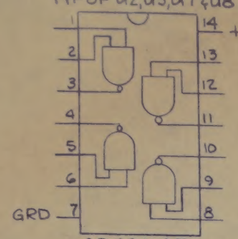
SCHEMATIC DIAGRAM OF
RMS METER - MODEL 1076

SIZE E | DWG NO 1076 | REV L
SCALE NONE | SHEET 1 OF 2

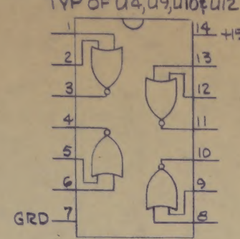
TYP OF U1



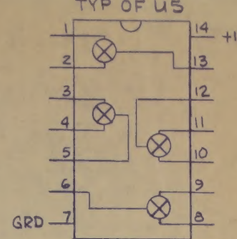
TYP OF U2,U3,U7 & U8



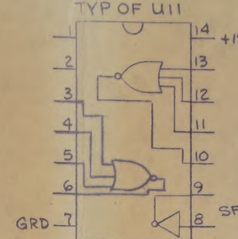
TYP OF U4,U9,U10 & U12



TYP OF U5

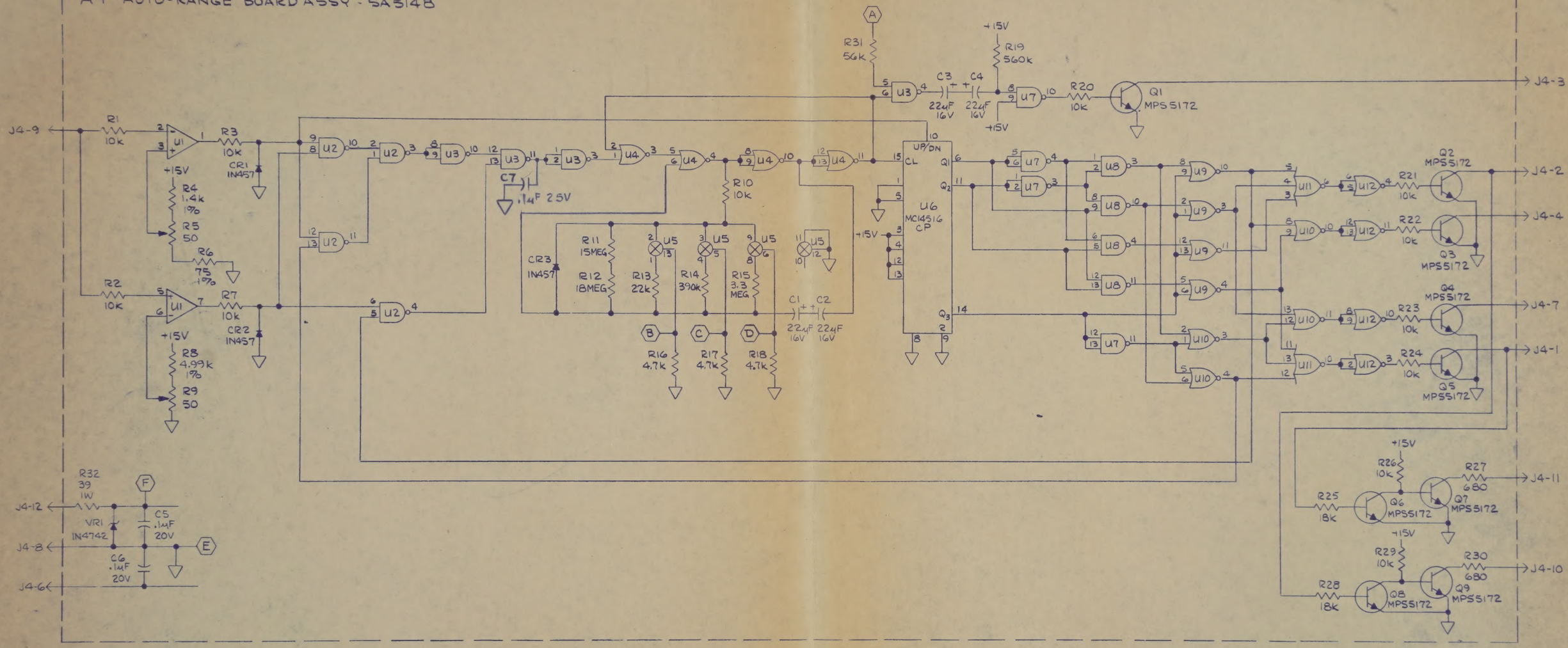


TYP OF U11



REVISIONS				
LTR	ECO	DESCRIPTION	DATE	APPROVED

A4 AUTO-RANGE BOARD ASSY - SA5148



SCHEMATIC OF AUTO-RANGE OPTION ONLY

ITEM	REQD.	PART NO.	DESCRIPTION
LIST OF MATERIAL			

REMOVE ALL BURRS AND SHARP EDGES UNLESS OTHERWISE SPECIFIED; MACHINE SURFACES TO 125 RMS PER MIL-STD-10A

THIS DOCUMENT CONTAINS CONFIDENTIAL INFORMATION OF THERMO-SYSTEMS INC. IN CONSIDERATION OF THE RECEIPT OF THIS DOCUMENT, THE RECIPIENT AGREES NOT TO REPRODUCE, COPY, USE OR TRANSMIT THIS DOCUMENT AND/OR THE INFORMATION THEREIN CONTAINED, IN WHOLE OR IN PART, OR TO SUFFER SUCH ACTION BY OTHERS, FOR ANY PURPOSE EXCEPT WITH THE WRITTEN PERMISSION OF THERMO-SYSTEMS INC.

DRAWN	D GLANDER
DATE	2-4-74
CHECKED	
APPROVED	

TOLERANCES UNLESS OTHERWISE SPECIFIED

DECIMALS	FRACTIONS	ANGLES
.X ±.030	±1/32	±1°
.XX ±.010		
.XXX ±.005		

MATL.

tsi THERMO-SYSTEMS INC.
2500 CLEVELAND AVE. N. ST. PAUL, MINNESOTA 55113

SCHEMATIC DIAGRAM OF RMS METER - MODEL 1076

SCALE	SIZE	DWG. NO.	REV.
NONE	B	1076	G

SHEET 2 OF 2

⬡ DENOTES WIRING PAD

ALL RESISTORS 1/4W AND/OR 5% UNLESS OTHERWISE SPECIFIED

ALL RESISTANCES IN OHMS

FIELD ENGINEERING OFFICES

HEADQUARTERS

THERMO-SYSTEMS, INC.
2500 N. Cleveland
St. Paul, Minn. 55113
(612) 633-0550

REGIONAL SALES OFFICE—
NEW ENGLAND, NEW YORK, NEW JERSEY, EASTERN PA.

THERMO-SYSTEMS, INC.
P. O. Box 221 — 3 Sharon Court
Ringwood, N.J. 07456
(201) 839-0720

EUROPEAN OPERATIONS OFFICE

TSI INTERNATIONAL INC.
Belgium 4711, Walhorn
Merolser, Strasse 82, Belgium
Phone: 087/851647

DOMESTIC FIELD ENGINEERING OFFICES

Albuquerque
TECHNOLOGY MARKETING ASSOCIATES, INC.
9611 Acoma S.E.
Albuquerque, New Mexico 87123
(505) 298-4321

Atlanta
CRAFT ASSOCIATES COMPANY
7603 Perimeter Center East
Atlanta, Georgia 30346
(404) 393-0400

Baltimore
GANS-FRYLING, INC.
12027 Scaggsville Rd.
Fulton, MD 20759
(301) 837-6311

Cleveland
INSTRUMENTATION SYSTEMS, INC.
21877 Euclid Avenue
Cleveland, Ohio 44117
(216) 486-0782

Dallas
ROGER MARTIN ASSOCIATES, INC.
P. O. Box 64513
Dallas, Texas 75206
(214) 361-8584

Dayton
INSTRUMENTATION SYSTEMS, INC.
3481 Office Park Drive
Dayton, Ohio 45439
(513) 294-2838

Denver
TECHNOLOGY MARKETING ASSOCIATES, INC.
Box 115
Parker, Colo. 80134
(303) 841-3435

Detroit
CARTER, MC CORMIC & PEIRCE, INC.
23995 Freeway Park Drive
Farmington, Michigan 48024
(313) 477-7700
Twx: 810-242-2986

Houston
ROGER MARTIN ASSOCIATES, INC.
P. O. Box 40161
Houston, Texas 77040
(713) 462-4077
TWX 910/881/3630

Huntsville
CRAFT ASSOCIATES COMPANY
P. O. Box 1053
Huntsville, Alabama 35807
(205) 837-0221

Kansas City
ENGINEERING SERVICES COMPANY
7830 State Line Road
Prairie Village, Kansas 66208
(913) 649-4000

Los Angeles
DALE-DAHL ASSOCIATES
2570 Mission Street
San Marino, California 91108
(213) 682-3417

Orlando
CRAFT ASSOCIATES COMPANY
P. O. Box 986
Maitland, Florida 32751
(305) 645-2242

Pittsburgh
INSTRUMENTATION SYSTEMS, INC.
201 Penn Center Boulevard
Pittsburgh, PA 15235
(412) 243-1111

Portland
MC LAREN INC.
5319 S.W. Canyon Court
Portland, Oregon 97221
(503) 297-2248

San Francisco
DALE-DAHL ASSOCIATES
2363 Boulevard Circle, Suite 6
Walnut Creek, California 94597
(415) 933-9595

Seattle
MC LAREN, INC.
P. O. Box 2029
1628 - 130th N.E.
Bellevue, Washington 98009
(206) 454-3400

St. Louis
ENGINEERING SERVICES COMPANY
8420 Delmar Blvd.
St. Louis, Missouri 63124
(314) 997-1515

Washington, D. C.
GANS-FRYLING, INC.
2062-14th Street North
Arlington, Virginia 22201
(703) 527-3262

INTERNATIONAL FIELD ENGINEERING OFFICES

AUSTRALIA
KENELEC SYSTEMS PTY. LTD.
142 Highbury Road, Burwood
Victoria, 3125, Australia
Cable: Kenelec-Melbourne
Phone: (03) 288-7100

AUSTRIA
UNIVERSAL ELEKTRONIK IMPORT
A-1080 Wien, Zeltgasse 3-5,
Austria
Telex: 75011 ELTRO A
Phone: 42-23-58

CANADA
WILLER ENGINEERING LIMITED
1800 Avenue Road
Toronto, Ontario, Canada M5M 3Z1
(416) 783-3373

WILLER ENGINEERING LIMITED
1179 Decarie Boulevard
Montreal, Quebec, Canada H4L 3M8
(514) 748-6169

FRANCE
MESUREUR
72-76 rue du Chateau des Rentiers
75 Paris 13e, France
Telex: 68461 (OMTEL D)
Phone: 589-66-41

INDIA
TRANS MARKETING ASSOCIATES
Nyloc House, 254 D-2 Dr. Annie Besant Rd.
Bombay 400 025, India
Cable: Lordex
Phone: 456231

IRAN
PARAVAHAN CO. LTD.
P. O. Box 11-1598
No. 325 Iran Novin Ave.
Tehran, Iran
Phone: 631162-637847
Cable: COMPARVAHAN

ISRAEL
KORN TECHNICAL AGENCIES LTD.
4, Shlomo Hamelech St.
P.O.B. 21028
Tel-Aviv, Israel
Phone: 03-287544
Telex: 03-2470 COINIL

ITALY
SOC. AN. NA. SAS
Via B. Panizza 9
I 20144 — Milano, Italy
Phone: 49-03-78, 43-28-17

JAPAN
KORITSU TRADING CO., LTD.
Fukushima Bldg., 20-1
Maruyamacho, Shibuya-ku
Tokyo 150, Japan

NIHON KAGAKU KOGYO CO., LTD.
2-1, Shimizu
Suito, Osaka, Japan

KUWAIT
ABDULLA MOHAMMAD AL-KHULAIFI
P. O. Box 3454
Kuwait, Arabia
Phone: 429691 - 420170

MEXICO
DALMA COMERCIAL, S.A.
Plaza Santo Degollado No. 10-104
Apartado 1410
Mexico 1, D.F.
Phone: 510-06-07
Cable: DALMACO

NETHERLANDS
Technisch Advies en Handelsburo J.J. Box B.V.
Oostzeedijk 138
Rotterdam 3016, Netherlands
Telex: 21649 (Maoil)
Phone: 010-125005/141371

NORWAY
ESTRONIC
Klokkerjordet 31
1364 Hvalstad, Norway
Phone: 782410
Cable: ESTRONIC, ASKER

PORTUGAL
SINTARMEL
Rua D. Estefania, 157/5.°
Lisboa - 1, Portugal
Phone: 53 75 91/2/3/4
Telex: 12789 SINTAR P

SPAIN
AUPOCA S.A.
Colombia, 34
Madrid - 16, Spain
Phone: 457 53 12
TWX: 23742 AUPOC E

SWEDEN
STROM ELECTRONICS
Snapphanevagen 10
175 34 Jarafalla, Sweden
Phone: 0758/171 40

SWITZERLAND
BRINDI AG
Postfach 230
4002 Basel, Switzerland
Phone: 061/427955

UNITED KINGDOM
PROSSER SCIENTIFIC INSTRUMENTS LTD.
Lady Lane Industrial Estate
Hadleigh, Ipswich, Suffolk, U.K.
Phone: 047-338-3005 (Hadleigh)
Telex: 987788 Ubraze.PSI HLGH

WEST GERMANY
BRINDI GMBH
Postfach 862
7850 Lorrach
West Germany
Telex: 63996 BRIND CH
Phone: Lorrach 10742

THERMO SYSTEMS INC.
2500 N. Cleveland
St. Paul, Minnesota 55113
(612) 633-0550
Telex: 297-482